Testing of a new morphing trailing edge flap system on a novel outdoor rotating test rig

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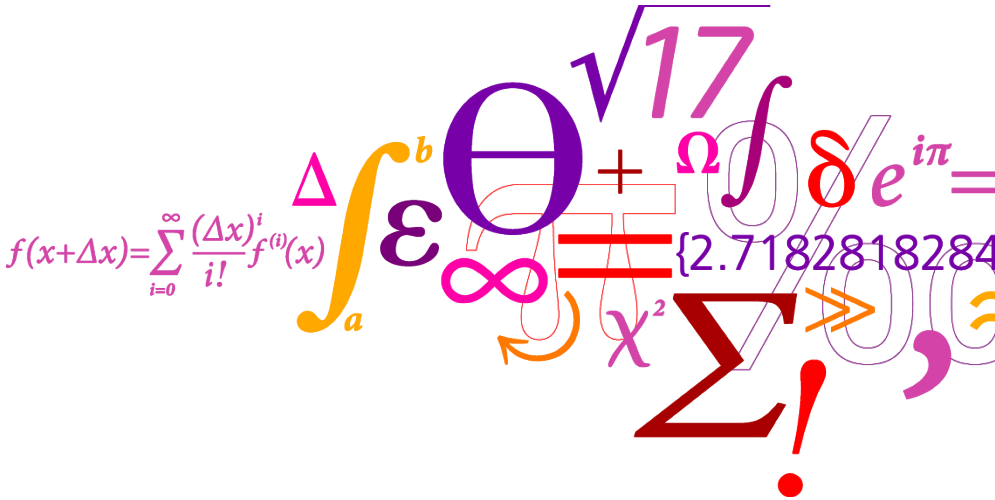
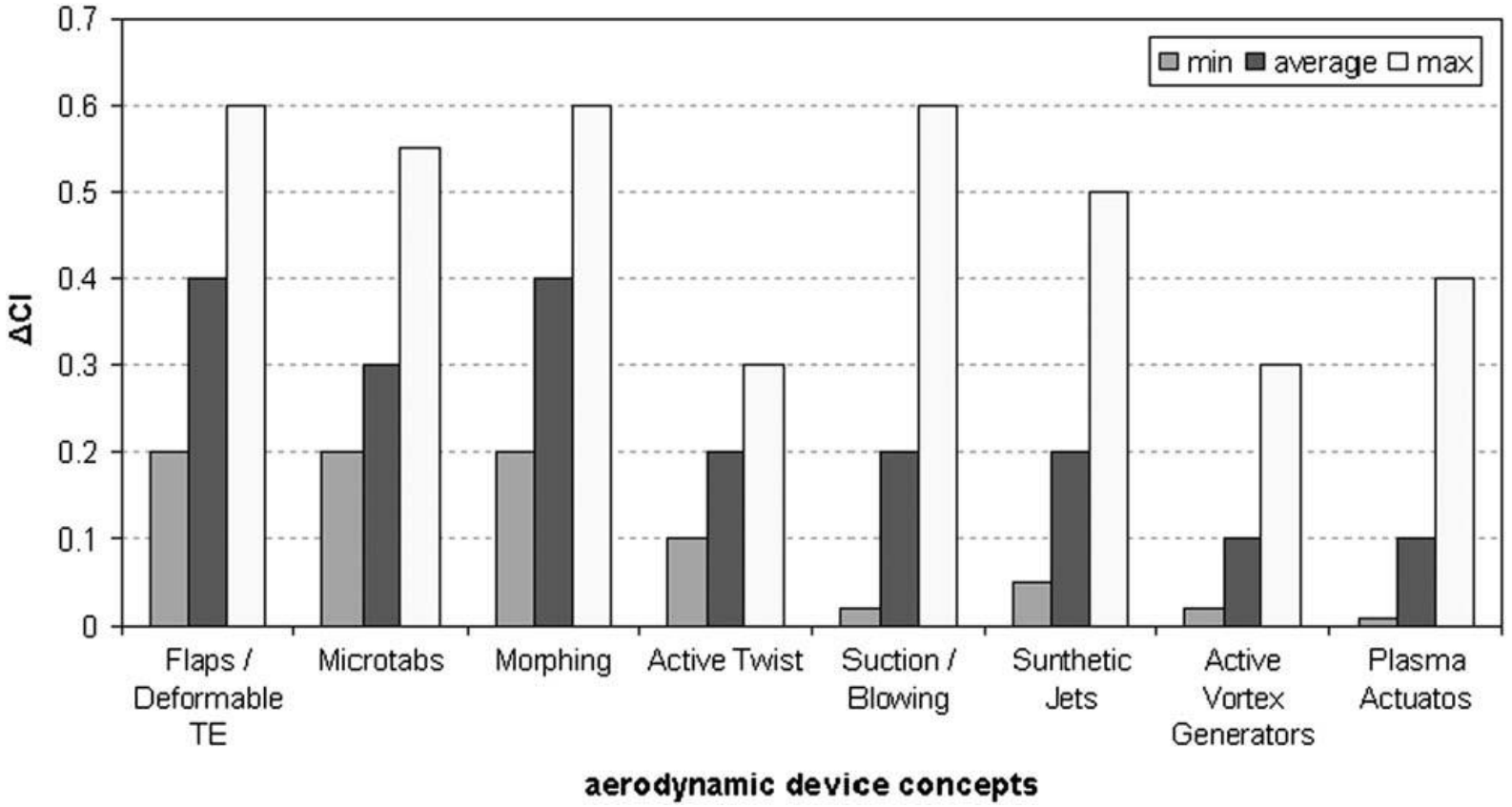


Why use flap control ?

Flaps are among the best devices for changing lift



Barlas, T.K., vanKuik, G.A.M., 2010, —Review of state of the art in smart rotor control research for wind turbinesll, Progress in Aerospace Sciences, vol. 46, pp. 1–27

Flap system technology

Strong requirements from the wind turbine industry to the technology

- ❑ robust and reliable (20 years lifetime)
- ❑ no metal parts
- ❑ no electronics
- ❑ no mechanical parts
- ❑ scalable to the large blade sizes (100m)

Piezzo electric actuators in wind tunnel exp. 2007 (DTU)

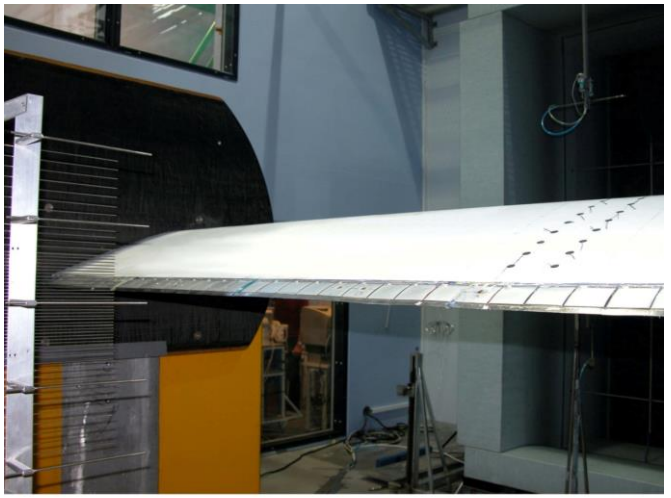


FIGURE C.2 THE TEST SECTION WITH THE TEST STAND AND THE WAKE RAKE DOWNSTREAM OF THE AIRFOIL SECTION.

Courtesy : SSP Technology

© *Siemens*

The Controllable Rubber Trailing Edge Flap CRTEF development

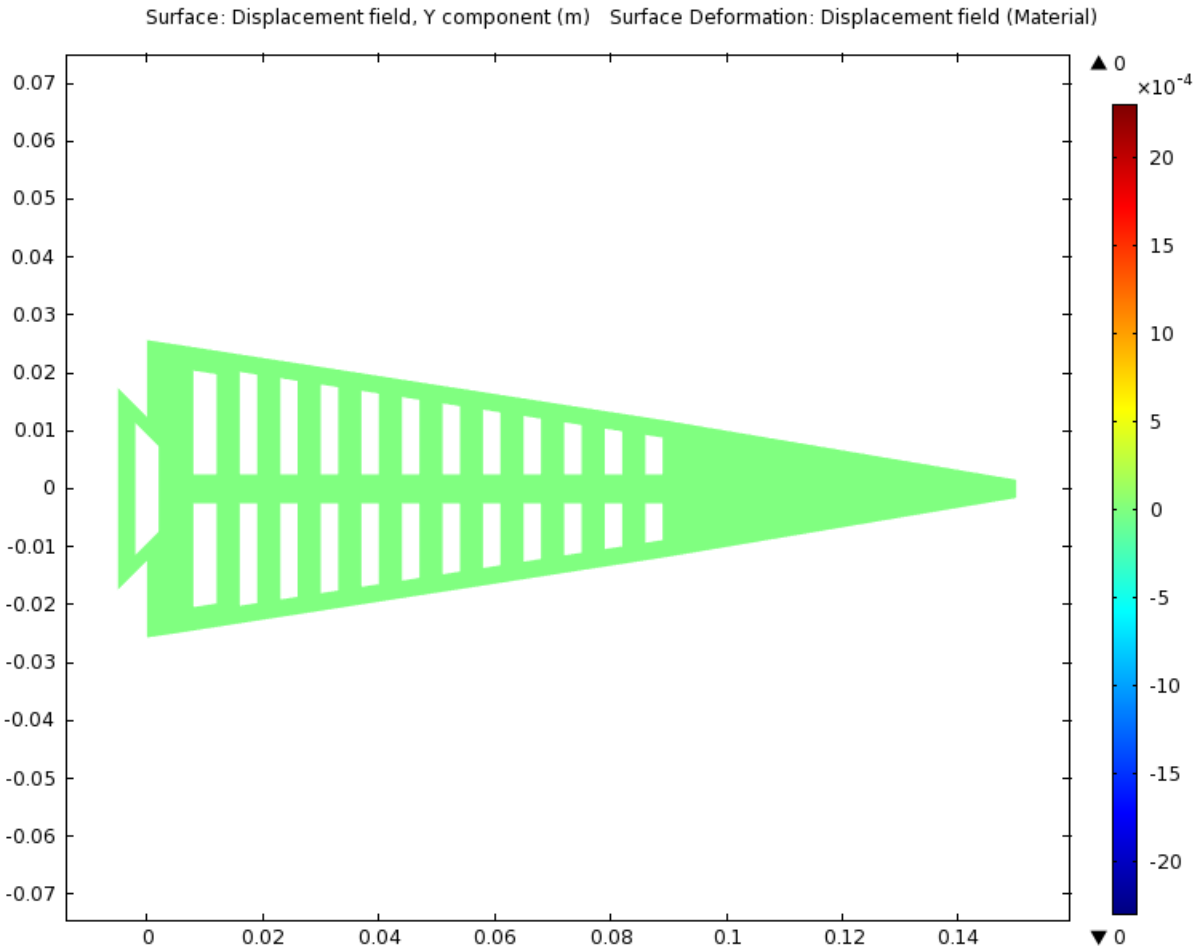
Development work started in 2006

Main objective: Develop a robust, simple controllable trailing edge flap

The CRTEF design:

A TE flap in an elastic material with a number of voids that can be pressurized giving a deflection of the flap

The Controllable Rubber Trailing Edge Flap CRTEF

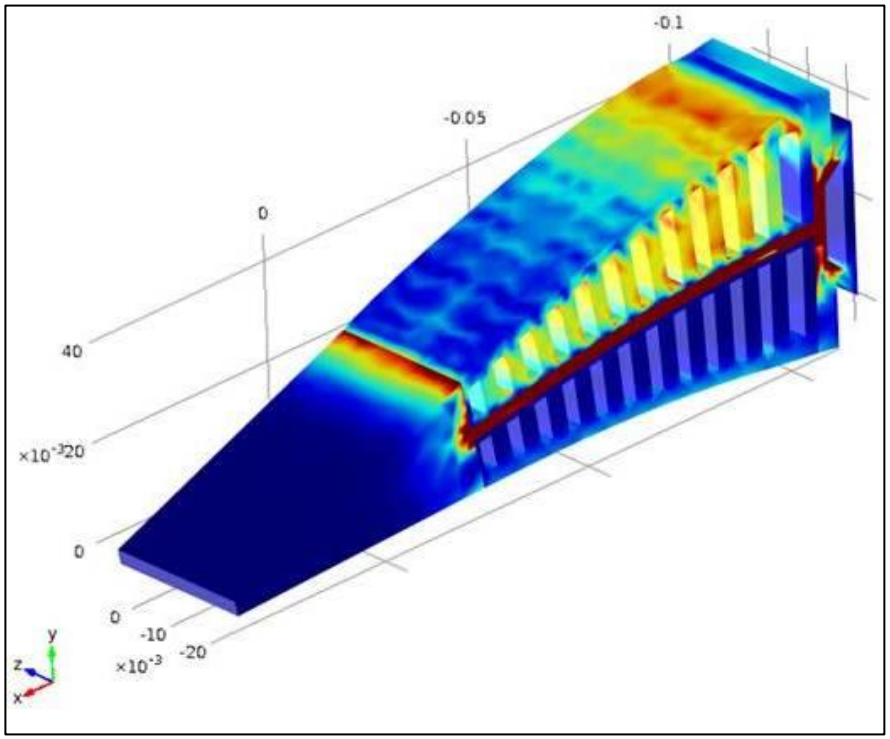


Some milestones in the CRTEF development

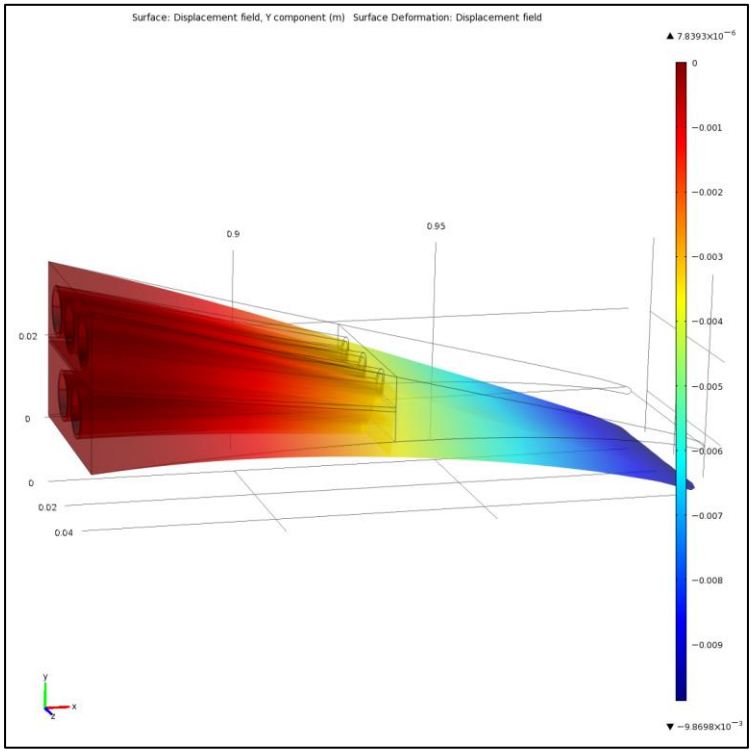
- in **2007** a 1m long prototype rubber trailing edge flap was tested – problems with its robustness
- in autumm **2008** promissing results with a 30 cm prototype with chordwise voids
- December **2009** wind tunnel testing of 2m long flap section
- March **2011 - 2014** the project ” Industrial adaptation of a prototype flap system for wind turbines –INDUFLAP ” was conducted

Two basically different designs have been investigated during the INDUFLAP project

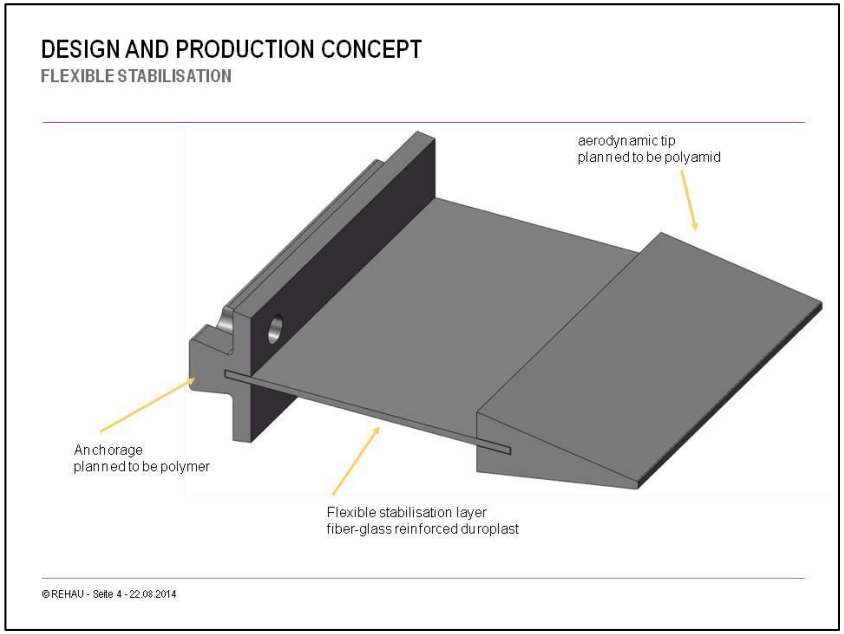
Prototype with spanwise voids - suited for manufacturing by extrusion



Prototype with chordwise voids – mold manufacturing in 2D and 3D



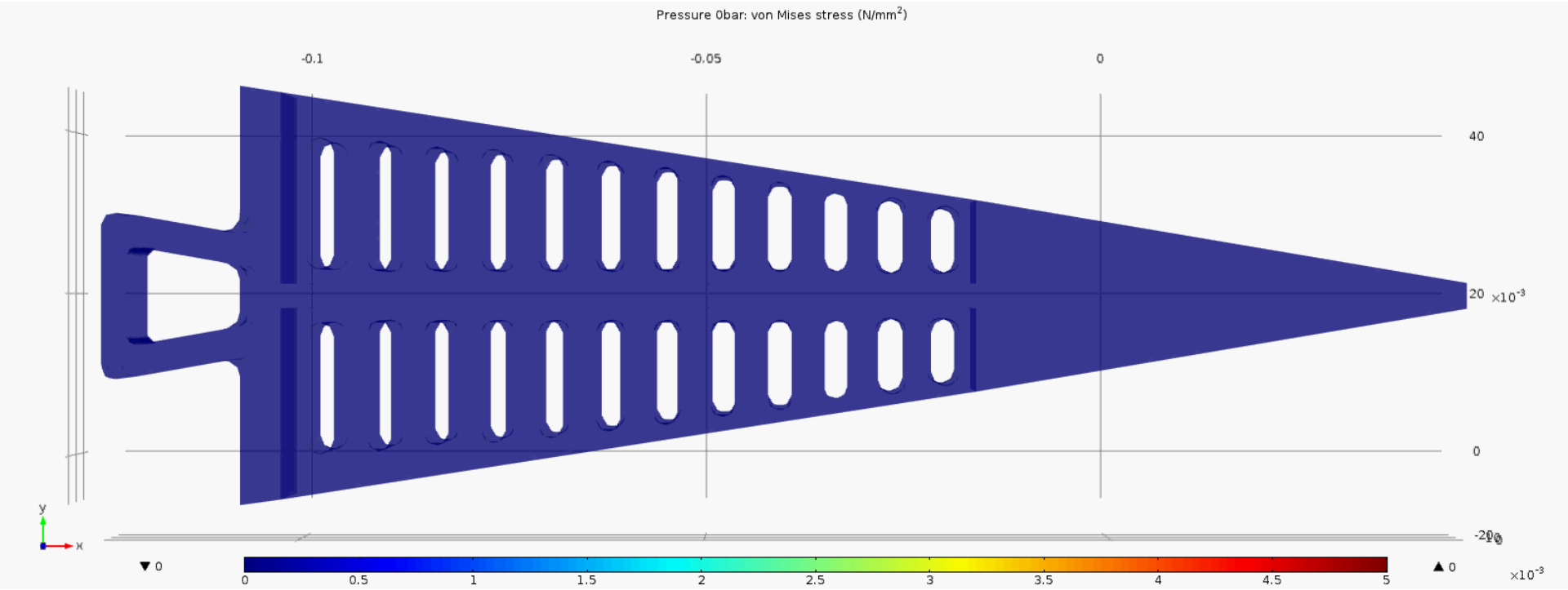
The flap design chosen for testing on a 2m span blade section



The load carrying part

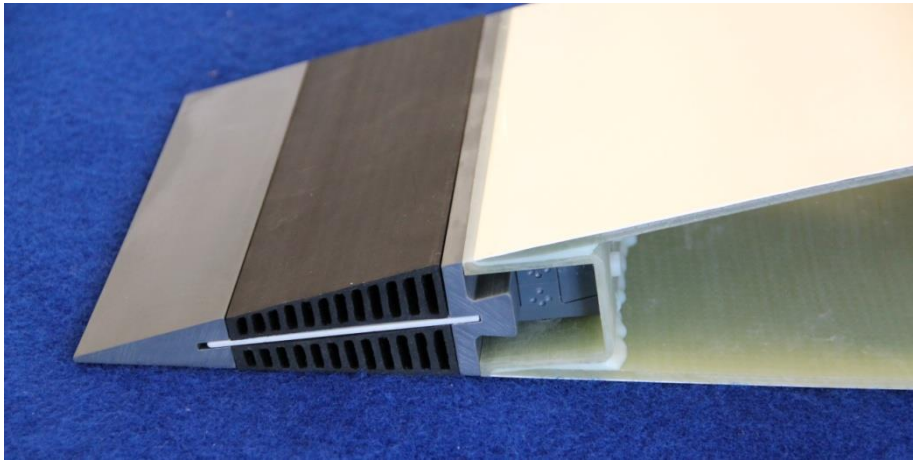
The two active parts, manufactured by extrusion, assembled with the load carrying part

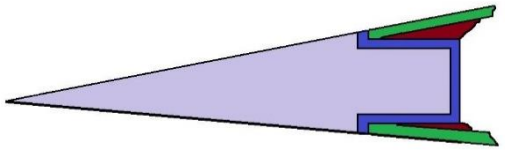
The flap design chosen for testing on 2m span blade section



Overall concept for blade with flaps

- Main blade is designed and manufactured without the trailing edge part (10-15% of chord)
- A spar is inserted at the TE with an attachment component for the flap
- From the region where flat back airfoils ends, flaps are used along the whole span out to the tip
- Acombination of passive flaps (3D mold manufactured) and 2D active flaps manufactured by an extrusion process are used





Testing

- testing prototypes in the laboratory – e.g. for flap angle and time response -- done (2008-2009)
- wind tunnel testing for measuring the aerodynamic performance -- done (2009)
- we developed a rotating test rig for testing the flap system in the rotating environment and with the real turbulent inflow – done (2013-2014)
- full scale tesing on a MW turbine - - to come

Rotating test rig

Based on a 100 kW turbine platform

Intended to minimize the gap between wind tunnel testing and fullscale testing

- ❑ testing in rotating environment with realistic g-loading
- ❑ real turbulent inflow
- ❑ combine pitch and flap control
- ❑ detailed aerodynamic pressure measurements

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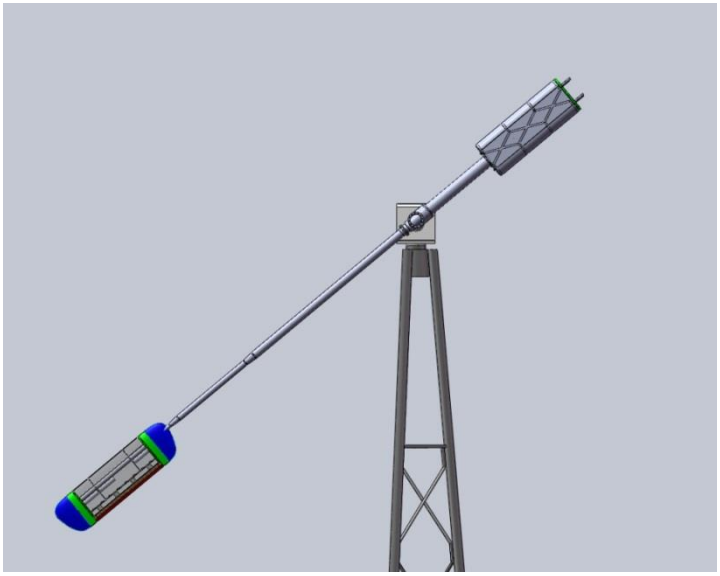
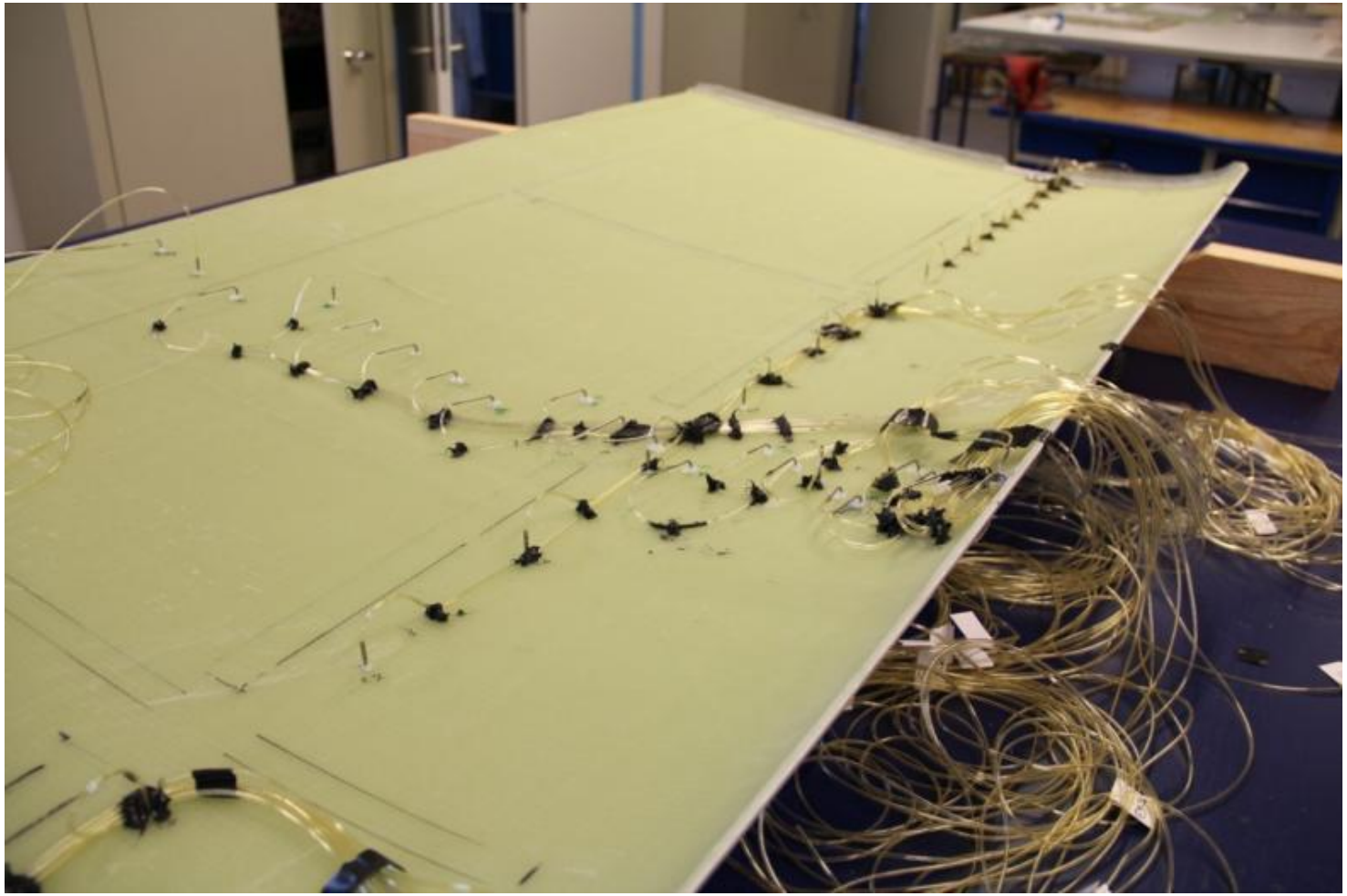


Blade section 2.2x1m with detailed instrumentation with pressure taps

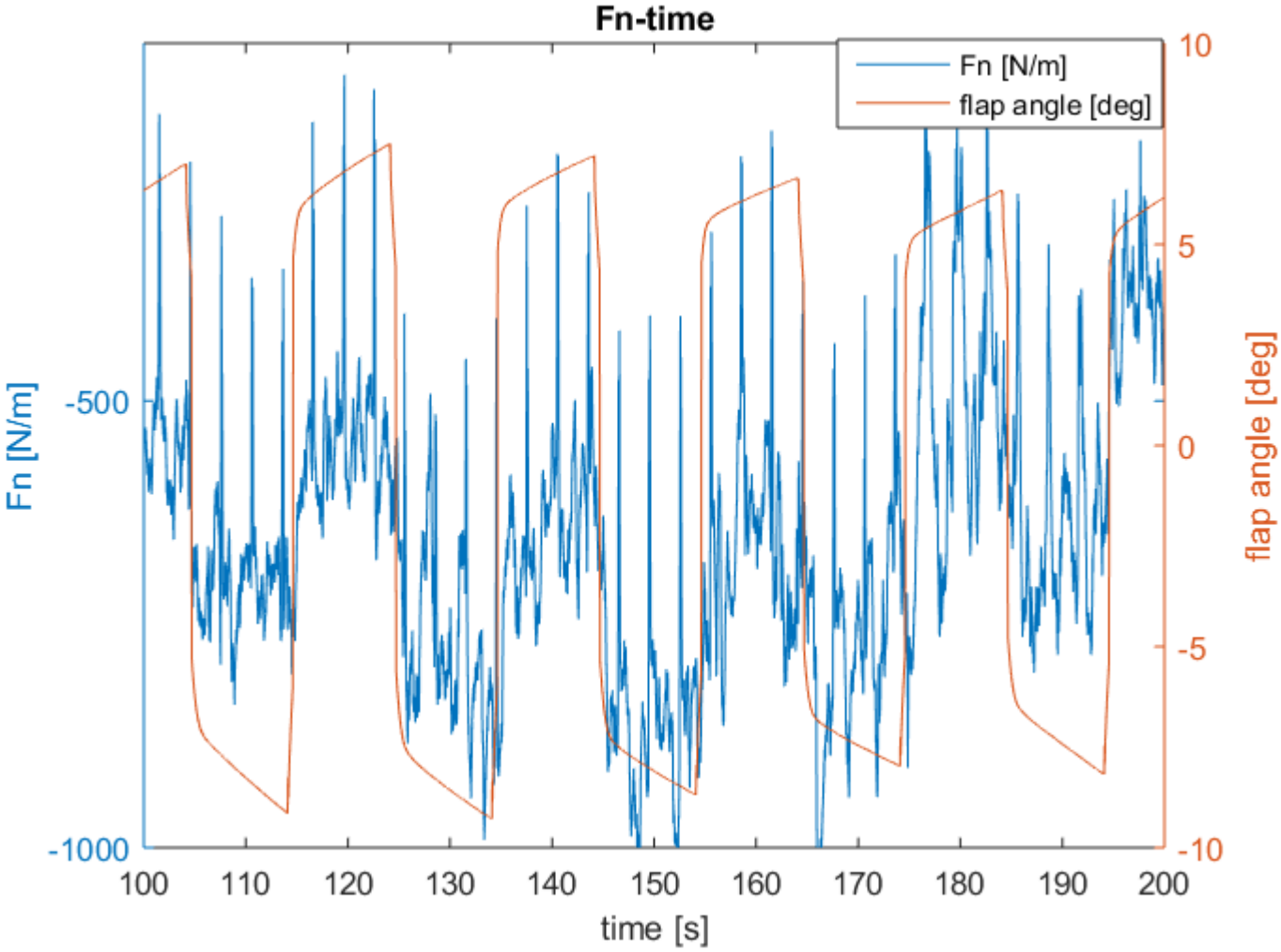


Boom installed in June 2014

Rotating test rig in operation September 2014

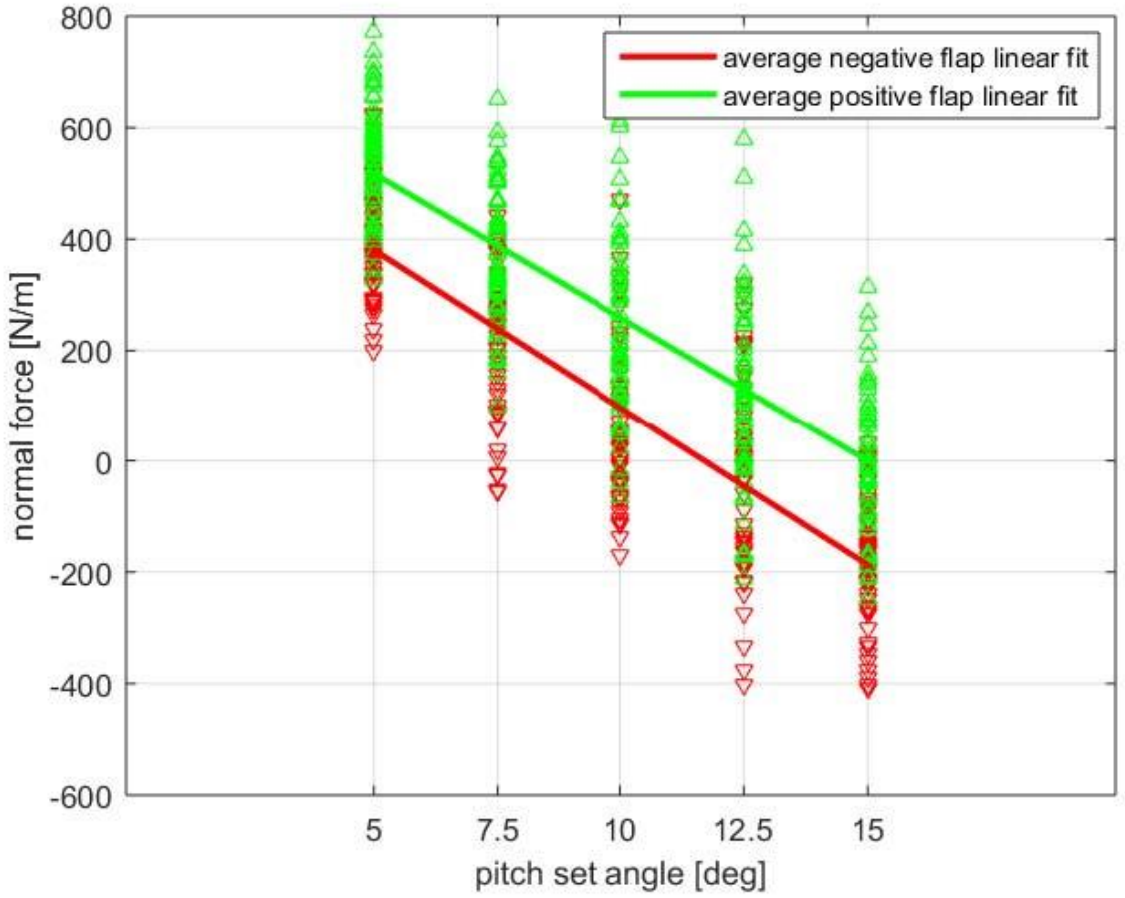
Results – downwind operation

Flap angle changed in steps at each 10 sec.



Results – compare flap and pitch action

Change in normal force from 15 deg. change in flap angle equals about 3 deg. change in pitch



Summary and outlook

- Successful industrial manufacturing of flap prototype by an extrusion process in a polymer material.
- Rotating tests of 2.2m flap section proved functioning up to 10g loading.
- Atmospheric testing on rotating test rig showed that 5deg. flap angle gave same change in loading as 1 deg. pitch.
- The next step involving an OEM aims at testing an active flap system on a MW turbine – project funded by the Danish EUDP programme ongoing.

Acknowledgement

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Thank you for your attention!